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Clinical Research

Open Surgery for Ruptured Abdominal Aortic Aneurysm — 38 Years Experience at an Academic Center in Chile

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Background: Few series of ruptured abdominal aortic aneurysm (RAAA) from Latin America have been published.
Objectives: To report the outcomes of RAAA treated with open surgical repair (OSR) in a University Hospital in Chile. Secondary objectives are the identification of prognostic factors and survival rates.
Methods: Retrospective review of consecutive RAAA patients treated with OSR between September 1979 and December 2017. Medical records, diagnostic images, and follow-up details were obtained. Statistical methods include multiple logistic regression analysis.
Results: One hundred and sixteen patients underwent OSR for RAAA. The average age was 72.3 years (54–95), 62.9% $\geq$ 70 years, and 81.9% male. Preoperative systolic pressure <90 mm Hg was present in 74 patients (63.8%), and 10 (8.6%) experienced cardiac arrest before surgery. Only 30.2% were known to have an AAA before rupture. The mean aortic diameter was 7.9 cm. Sixteen patients had juxtarenal aneurysms (13.8%). The rupture was intra or retroperitoneal in 111 cases (95.7%), there were 4 fistulas to neighboring veins and one into the duodenum. Reconstruction included tubular graft in 39.7% and bifurcated in 58.6%. The estimated mean blood loss was 3,456 ± 2,768 mL (median 3,000). Mean mechanical ventilation was 7.4 ± 12.0 days and hemodialysis requirement in 21.8%. Six patients died during surgery and other 24 during the first postoperative month or in hospital, for an overall mortality rate of 25.9%. Age $\geq$70 years ($P < 0.01$), blood pressure less than 90 mm Hg ($P = 0.03$) and dialysis ($P < 0.01$) were associated with higher 30-day mortality rates. The survival rate was 68.0, 65.3, 44.3, and 25.2% at 1, 2, 5, and 10 years, respectively.
Conclusions: EVAR for RAAA is not affordable in every country. Outcomes of open RAAA repair at our institution are similar to results reported recently for OSR by the USA and European Medical centers.

INTRODUCTION

Ruptured abdominal aortic aneurysm (RAAA) remains a condition with high morbidity and mortality worldwide. Comparative studies show that the Latino population in the USA has worse aortic surgery outcomes.[1,2] Few series of RAAA from Latin American countries have been published.[3–5]

Open surgical repair (OSR) of RAAA has been historically associated with 40 to 50% mortality,[6,7] although better results have been reported in recent studies.[8,9] On the other hand, EVAR has shown favorable outcomes for the treatment of RAAA,

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but it is not always technically feasible, and real-life advantage has been questioned in prospective studies.[8–10]

Although EVAR is regularly used for elective AAA repair in our country, aortic endografts cannot be used in emergencies with unstable patients as they are not readily available on OR shelves. Additionally, the cost is an important factor to consider when Public Health is responsible for giving rationality to a tight budget.

Our aim is to review our experience with OSR for RAAA patients in a period of more than 3 decades, analyze and identify clinical variables that could correlate with higher mortality risk.

PATIENTS AND METHODS

A retrospective study of 116 consecutive patients treated with OSR for RAAA by our department staff vascular surgeons between September 1979 and December 2017. The study was approved by our local Institutional Review Board. Electronic registries, clinical records, diagnostic images, and follow-up notes were reviewed, and a database was compiled. We included all patients operated with a documented rupture of abdominal aortic wall, who survived to reach the operating room.

All surgeries were performed by one of six U.S. trained vascular surgeons. Patients who expired before surgery, symptomatic but nonruptured AAA, and isolated iliac, suprarenal, or thoracoabdominal-ruptured aneurysms were excluded.

Medical consults, diagnostic tests, operative data, blood product transfusions, patient length of stay (LOS), morbidity, mortality, and follow-up were obtained. The rupture was defined as either a defect in the aneurysm wall with extravasation of blood to the retroperitoneum, or peritoneal cavity, or fistula to adjacent duodenum or major veins. Hypotension was considered as a systolic blood pressure less than 90 mm Hg on admission or before surgery. Surgical mortality was defined as either in-hospital, during, or after surgical AAA repair, or within 30 days. Morbidity was defined as postoperative complications including acute renal insufficiency (AKI criteria[11]), respiratory failure (ventilatory support for 3 or more days), infections including pneumonia documented by positive bronchoalveolar cultures, sepsis in febrile patients with positive blood cultures, and coagulopathy (thrombocytopenia $<60{,}000/mm^3$ and clinical bleeding).

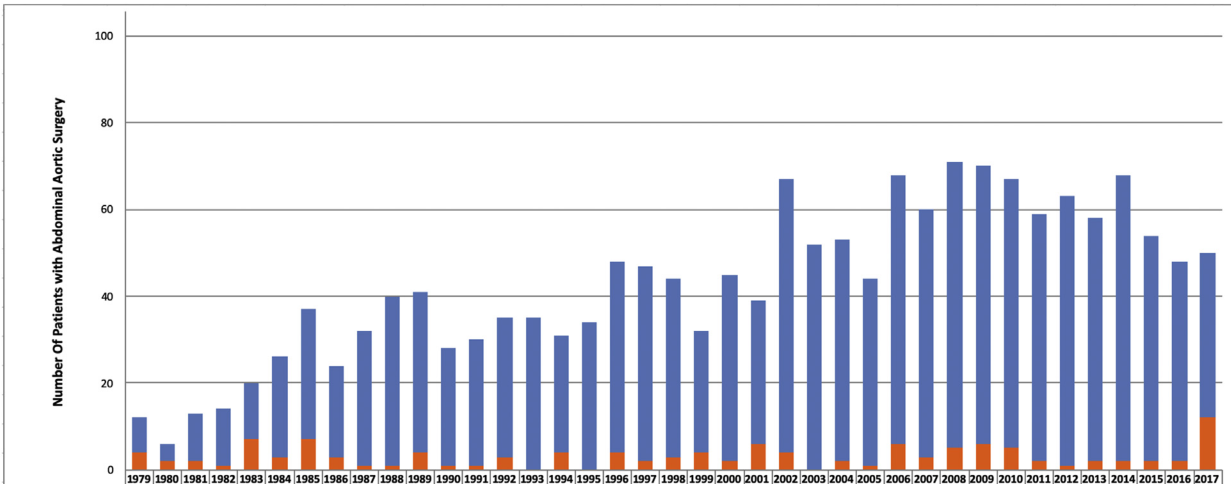
Results are reported as frequency and absolute numbers for categorical variables and mean ± standard deviation (SD) for numerical variables. Statistical evaluation was performed by descriptive statistic methods, including measures of central tendencies and variability, and analytic methods, including *t*-tests, Wilcoxon test, Pearson test, and Kolmogorov-Smirnov test. A P-value <0.05 was considered statistically significant. Pre, intra, and postoperative factors related to mortality were analyzed, excluding patients with 10% or greater missing information. Risk factors represented by categorical variables were evaluated with χ^2 or Fisher's exact tests. Risk factors represented by numerical variables were tested for normality with a Kolmogorov-Smirnov test. The effects of normal continuous variables were assessed with 2 sample-tailed *t*-tests. Wilcoxon rank-sum test was used when the data were not normally distributed. Multiple logistic regression was used for multivariate analysis to evaluate the effects of the risk factors previously selected. The stepwise selection was used to select proper, most important, and significant variables between those previously selected. Finally, a logistic regression model adjusted for dialysis, hypotension, age over 70, and days hospitalized, was developed, to compare 30-day mortality over the 38-year study period. All analyses were conducted with R software (The R Foundation for Statistical Computing http://www.R-project.org). Survival was studied using both the actuarial and Kaplan–Meier methods.

RESULTS

Between September 1979 and December 2017, a total of 1,665 AAA were operated on by our team: 1,423 (85.5%) asymptomatic elective AAA, 448 of them with EVAR starting in 1997; 122 (7.3%) treated for symptomatic nonruptured AAA and 120 for RAAA. Only 4 RAAA patients were treated with EVAR, and 116 (7.0%) were treated with OSR. This last group is the source of our present report.

Total abdominal aortic surgery and the number of ruptured versus nonruptured patients per year are shown in Figure 1. One-third of all aortic surgeries were for RAAA in the first 2 years of the study, with an average of 13.2% of RAAA between 1979–1989. In the following decades, the relation was stable, 1990–1999: 6.0%, 2000–2009: 6.2%, 2010–2017: 6.4%. The mean number of RAAA operated per year was 3.1 ± 2.4.

The mean age of the 116 RAAA patients was 72.3 years (range 54–95), and 95 (81.9%) were men. Seventy-three patients (62.9%) were



	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997
TOTAL AAA	12	6	13	14	20	26	37	24	32	40	41	28	30	35	35	31	34	48	47
%RUPTURED	33	33	15	07	35	12	19	13	03	03	10	04	03	09	00	13	00	08	04
NON-RUPTURED	8	4	11	13	13	23	30	21	31	39	37	27	29	32	35	27	34	44	45
RUPTURED	4	2	2	1	7	3	7	3	1	1	4	1	1	3	0	4	0	4	2

	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
TOTAL AAA	44	32	45	39	67	52	53	44	68	60	71	70	67	59	63	58	68	54	48	50
%RUPTURED	07	13	04	15	06	00	04	02	09	05	07	09	07	03	02	03	03	04	04	24
NON-RUPTURED	41	28	43	33	63	52	51	43	62	57	66	64	62	57	62	56	66	52	46	38
RUPTURED	3	4	2	6	4	0	2	1	6	3	5	6	5	2	1	2	2	2	2	12

Fig. 1. Number of patients with ruptured and nonruptured AAA operated per year.

≥70 years and 24 (20.7%) ≥ 80 years. The demographics are listed in Table I and clinical presentation in Table II. Abdominal pain was present in all patients. Systolic blood pressure below 90 mm Hg on admission or before surgery was found in 74 patients (63.8%), 10 patients experienced cardiac arrest on arrival or before undergoing surgery (8.6%). The classic triad of abdominal pain, shock, and a pulsatile abdominal mass was present in 49.1% of patients. Thirty-five patients (30.2%) were known to have an AAA prior to its rupture. The diagnosis was established exclusively by clinical presentation in 26 patients (22.4%), abdominal CT in 61 (52.6%), abdominal ultrasound in 15 (12.9%), both imaging studies in 6 (5.2%) and was not registered in 8 patients. Laboratory findings on admission are mean creatinine level of 1.7 ± 1.3 mg/dL and hematocrit of 32.4 ± 9.1%.

A mean of 44.0 hr elapsed from the time of symptoms onset to admission to the emergency department (median 15 hr, range 1 hr—15 days); 41.4% of the patients were transferred from other hospitals.

The rupture was intra or retroperitoneal in 111 cases (95.7%); there were 2 fistulas to the iliac veins, one to the inferior vena cava, one to the left renal vein, and one primary aortoduodenal fistula. The mean aortic diameter was 7.9 cm (3.5—13). Sixteen patients had juxtarenal aneurysms (13.8%). Etiology was a degenerative disease in 107 cases, inflammation in 6, chronic dissection in 2, and Erdheim disease in one patient.

Table I. Comorbid conditions in 116 patients with RAAA

Smoking	72 (62.1%)
Hypertension	69 (59.5%)
Coronary heart disease	37 (31.9%)
COPD	30 (25.9%)
Peripheral arterial disease	20 (17.2%)
Dyslipidemia	17 (14.7%)
Obesity	14 (12.1%)
Diabetes mellitus	13 (11.2%)
Cardiac arrhythmia	12 (10.3%)
Renal failure	12 (10.3%)
Stroke	11 (9.5%)
Cancer	5 (4.3%)
Cirrhosis	4 (3.5%)
Venous thrombo-embolic disease	1 (0.9%)
Hemophilia	1 (0.9%)
Unknown	3 (2.6%)
Previously known AAA	35 (30.2%)

Initial proximal control was obtained by supraceliac clamping in 3 patients, suprarenal in 26 (22.4%), and infrarenal in 77 (66.4%). Intraluminal control with a large 30 ml Foley catheter balloon was obtained in 8 patients. No data was registered in 2 patients; one of them died during surgery. No thoracic cross clamping was performed. We used a tubular graft repair in 46 cases (39.7%) and bifurcated in 68 cases (58.6%). Two patients expired before a graft was inserted.

The mean estimated blood loss was 3,456 ± 2,768 mL (median 3,000; range 500—

Table II. Clinical presentation in 116 patients with RAAA

Cardiac arrest	4 (3.4%)
Symptoms	
Pain	116 (100%)
Abdominal	61
Lumbar	25
Both	30
Syncope	51 (44.0%)
Vomiting	7 (6.0%)
Signs	
Palpable abdominal mass	75 (64.7%)
Hypotension	74 (63.8%)
Distal malperfusion	61 (52.6%)
Pallor	57 (49.1%)
Associations	
Pain + Abdominal Mass + Hypotension	57 (49.1%)

Table III. Mortality causes

30 day—hospital mortality causes (116 patients)	
Sepsis	9 (7.8%)
Multiple organ failure	6 (5.2%)
Intraoperative	6 (5.2%)
Cardiac	4 (3.4%)
Coagulopathy	3 (2.6%)
Unknown	2 (1.7%)
Total	30 (25.9%)
Long-term mortality causes (63/86 Patients)	
Cardiac	17 (27.0%)
Myocardial infarction	10
Cancer	8 (12.7%)
End-stage COPD	7 (11.1%)
Respiratory infections	6 (10.0%)
Stroke	4 (6.3%)
Complicated thoracic aortic aneurysm	3 (4.8%)
Pulmonary embolism	3 (4.8%)
End-stage renal disease	3 (4.8%)
Other infections	2 (3.2%)
Hemorrhagic	2 (3.2%)
Mesenteric thrombosis	1 (1.6%)
Dementia	1 (1.6%)
Not Specified	6 (10.0%)

12,600). The mean duration of surgery was 229.4 ± 79.4 min (median 220; range 105—405), and mean aortic clamp time was 90.9 ± 55.0 min (median 75; range 29—270). Forty-six concomitant procedures were performed in 39 patients (35.5%) (Supplementary Table I), and the most frequent was lower extremity embolectomy. The mean pre, intra and postoperative packed red blood cells and/or whole blood transfusions were 5.8 ± 7.3 units per patient (median 4; range 0—36), 6.7 ± 4.8 units (median 6; range 0—24), and 3.1 ± 6.0 units (median 2; range 0—47), respectively.

Table IV. Postoperative complications in 110 surviving patients (*N*, %)

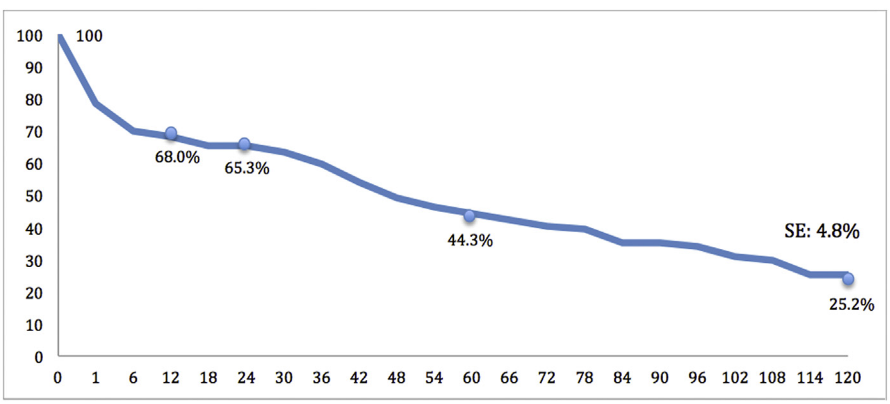
Respiratory	54 (49.1%)
Infections	49 (44.5%)
Renal failure	45 (40.9%)
Dialysis	24 (21.8%)
Cardiac	41 (37.3%)
Arrhythmia	33 (30.0%)
Acute myocardial infarction	10 (9.1%)
Cardiorespiratory arrest	3 (2.7%)
CHF	2 (1.8%)
Colon ischemia	13 (11.8%)
Sepsis	12 (10.9%)
Coagulopathy	11 (10.0%)
Gastrointestinal bleeding	8 (7.3%)
Hepatic failure	7 (6.4%)
Diarrhea	6 (5.5%)
MOF	6 (5.5%)
Lower extremity embolism	5 (4.5%)
DVT/PE	4 (3.6%)
Neurological	4 (3.6%)
Re-interventions	22 (20.0%)
Colectomy	6 (5.5%)
Hemoperitoneum	5 (4.5%)
Second-look	5 (4.5%)
Lower extremity ischemia	3 (2.7%)
Cholecystostomy/ectomy	3 (2.7%)
Retroperitoneal drainage	2 (1.8%)
IVC filter	1 (0.9%)
Fasciotomy	1 (0.9%)
Bowel obstruction	1 (0.9%)
No complications	18 (16.4%)

Average LOS was 21.6 ± 22.9 days (median 13; range 1—128), with an average intensive care unit stay of 12.9 ± 15.0 days (median 8; range 1—86). Support measures included mechanical ventilation for a mean of 7.4 ± 12.0 days (median 3; range 0—86), administration of vasopressors in 69.0%, and hemodialysis in 21.8%.

Among the 116 patients, 6 died during the operation and other 24 during the first month or in hospital, for an overall mortality rate of 25.9%. Causes of death are listed in Table III. Sepsis and multisystem organ failure (MOF) are the leading causes of death. Postoperative complications occurred in 92 of the surviving patients (83.6%); the most common were respiratory, infectious, renal, and cardiac complications. Twenty-seven early re-interventions were performed in 22 patients (20.0%) (Table IV). Mortality decreased from 31.4% before 1990 to 19.2% between 2010 and 2017 ($P = 0.67$), total morbidity has not changed over time ($P = 1.00$) (Table V).

Table V. Analysis of morbidity and mortality in decades

	1979–1989 (n = 35)		1990–1999 (n = 22)		2000–2009 (n = 33)		2010–2017 (n = 26)		
	69.8 ± 8.5 years		72.3 ± 10.4 years		75.9 ± 8.0 years		71.2 ± 9.1 years		
Outcomes	*n*	%	*n*	%	*n*	%	*n*	%	*P* value
Mortality									
Total	11	31.4	7	31.8	7	21.2	5	19.2	0.67
Morbidity									
Respiratory	22	66.7	11	55.0	20	60.6	13	54.2	0.77
Infections	11	33.3	8	40.0	17	51.5	13	54.2	0.34
Hemodialysis	9	27.3	3	15,0	5	15.2	7	29.2	0.45
Cardiac	10	30.3	8	40.0	19	57.6	4	16.7	0.01
Colon ischemia	1	3.0	4	20.0	5	15.2	3	12.5	0.21
Coagulopathy	3	9.1	1	5.0	6	18.2	1	4.2	0.38
Total	29	82.9	18	81.8	29	87.9	22	84.6	1.00



Month	1	6	12	18	24	30	36	42	48	54	60	66	72	78	84	90	96	102	108	114	120
Patients at Risk	91	81	76	70	69	67	63	56	51	48	46	42	40	39	33	33	32	29	26	21	21

Fig. 2. Survival curve of 116 RAAA patients. SE, standard error.

During a mean follow up of 78.0 ± 70.9 months (range 1–371), 63 patients died (73.3%) and 3 patients were lost to followup. Table III shows the causes of late deaths; cardiac, cancer, and end-stage COPD are responsible for half of them. Figure 2 shows curve and actuarial survival of 68.0, 65.3, 44.3, and 25.2% at 12, 24, 60, and 120 months, respectively.

Table VI shows the univariate analysis identified factors that correlated with mortality. Significant univariate predictors of death were age ≥70 years ($P < 0.01$), preoperative hypotension ($P < 0.01$), need of dialysis after surgery ($P < 0.01$), coagulopathy ($P < 0.01$) and preoperative cardiac arrest ($P = 0.04$).

By logistic regression analysis, overall hospital deaths were only related to age ≥70 years ($P < 0.01$), hypotension ($P = 0.03$) and dialysis ($P < 0.01$) (Table VI).

DISCUSSION

Currently, the best treatment for RAAA is under debate, and new evidence is continuously appearing. EVAR has shown better results in several single-center observational studies,[12–14] but it cannot be offered to all patients. Pitfalls of this technique are anatomic limitations in RAAA that allow only 40 to 60% of patients to meet IFU requirements,[8,15] severely hypotensive patients might not be able to undergo a CT-scan, no clear economical advantage for endovascular over OSR,[16] and EVAR has not shown to reduce late mortality.[17,18]

Time for repair is perhaps one of the most significant variables in outcome since it has been reported that 12.5% of RAAA will die within 2 hr of admission. The median time from admission to death has been reported as 10 hr 45 min.[13] EVAR is

Table VI. Analysis of factors affecting RAAA mortality rate univariate test in numerical variables

Factor	Alive *n*	Alive mean ± SD	Dead *n*	Dead mean ± SD	*P*
Age	83	71.0 ± 9.1	28	76.6 ± 7.9	**<0.01**
Mean AAA size (mm)	83	80.0 ± 18.2	28	76.3 ± 23.0	0.39
	No.		% Deaths		
Univariate test in categorical preoperative & intraoperative variables					
Age ≥70 years					
Yes	70		35.7%		**<0.01**
No	41		7.3%		
Gender					
Female	21		28.6%		0.91
Male	90		24.4%		
Known AAA					
Yes	33		27.3%		0.99
No	77		24.7%		
Unknown	1		-		
COPD					
Yes	30		13.3%		0.13
No	81		29.6%		
CAD					
Yes	36		33.3%		0.26
No	75		21.3%		
Chronic renal insufficiency					
Yes	12		33.3%		0.74
No	99		24.2%		
PAD					
Yes	20		15.0%		0.38
No	91		27.5%		
Syncope					
Yes	48		29.2%		0.86
No	62		22.6%		
Unknown	1		-		
Systolic blood pressure <90 mm Hg					
Yes	69		37.7%		**<0.01**
No	42		4.8%		
Cardiac arrest - pre					
Yes	8		50.0%		0.21
No	103		23.3%		
Infrarenal clamping					
Yes	73		19.2%		0.07
No	37		37.8%		
Unknown	1		-		
Bifurcated graft					
Yes	68		14.7%		0.06
No	41		29.3%		
Transfer					
Yes	44		20.5%		0.47
No	67		28.4%		
Cardiac arrest - all					
Yes	20		45.0%		**0.04**
No	91		20.9%		
Univariate test in categorical postoperative variables					
Cardiac Event					

(*Continued*)

Table VI. Continued

Factor	Alive		Dead		P
	n	mean ± SD	*n*	mean ± SD	*P*
Yes	41		22.0%		1.00
No	68		19.1%		
Dialysis					
Yes	24		54.2%		**<0.01**
No	85		11.8%		
Infections					
Yes	49		14.3%		0.18
No	60		26.7%		
Sepsis					
Yes	12		33.3%		0.47
No	97		19.6%		
GI bleed					
Yes	8		37.5%		0.46
No	101		19.8%		
Coagulopathy					
Yes	11		72.7%		**<0.01**
No	98		15.3%		
Colon ischemia					
Yes	13		23.1%		1.00
No	96		20.8%		
Colectomy					
Yes	6		33.3%		0.81
No	103		20.4%		
	Regression coefficient		Odds ratio		
Multivariate test					
Age ≥70 years	1.79		5.98		**<0.01**
Systolic blood pressure <90 mm Hg	2.52		12.47		**0.03**
Dialysis	3.89		49.07		**<0.01**
Coagulopathy	1.18		3.26		0.22
Cardiac arrest - all	0.36		1.82		0.64

Bolded values are statistically significant.

difficult for us to do in RAAA patients that present unstable or hypotensive since these patients cannot wait for the device to be delivered for prompt repair. Costs, insurance, reimbursement, and hospital policies precluded emergent EVAR and explained why most patients are treated with OSR at our institution. In some developed countries, OSR is still the main operative technique for RAAA.[15] In this series, only 4 patients with RAAA were treated with EVAR, and all were stable at admission.

Another aspect to consider is the role of OSR repair in vascular surgery training. Programs are responsible for proper training in emergency OSR of the aorta. Training of vascular surgery residents in elective OSR of the aorta is currently threatened even in hospitals linked to University programs.[19,20] Outcomes of OSR in RAAA are better in teaching hospitals[19] and high-volume surgeons.[21] Meltzer et al. showed that the surgeon's volume has an impact in OSR but not in EVAR for RAAA.[22]

There is no abdominal aortic aneurysm screening program in Chile. The number of abdominal aortic surgeries per year in our institution, and the proportion of RAAA are shown in Figure 1. In the last year of the study, we did surgery in 12 RAAA cases, 11 open and one endovascular (24% of all 2017 AAA), and half of them were transferred from other hospitals, based on a recent agreement with the Public Health System. This was the year with more RAAA operated and sixfold increase compared to previous years, and the reason that prompted this study.

Mortality in elective OSR for AAA in our group has been reported 2.1% over a 20-year period.[23] Surgical outcomes with low mortality rate of 25.9% in this RAAA series could be explained by the stability of the patients treated, considering that 41.4% of the admissions were transferred from other hospitals and the time between onset of symptoms to ER admission was 44.0 hr, which is longer than reported by other studies.[24–26] Hypotension at admission was present in 54.2% of transferred patients and in 69.6% in primary consulted ones ($P = 0.08$), therefore transferred patients were not necessarily stable ones.

Another consideration is the uniform and consistent treatment of RAAA patients at our institution. Along almost 4 decades of treatment of RAAA, basic principles have been expeditious preoperative management including permissive hypotension, anesthesia by experienced cardiovascular anesthesiologists, hypothermia prevention, and simultaneous anesthetic induction with the skin incision and experienced surgeons. Appropriate surgical technique used included midline laparotomy, initial digital dissection to avoid renal or inferior vena cava injury, prompt infrarenal aortic clamping if feasible, avoidance of supraceliac clamping if possible, careful handling of the aorta and iliac arteries, selective systemic heparin use in more stable patients versus local distal intra-arterial heparin, transfusion of blood products after aortic control, aorto-aortic preferred over bifurcated bypass when possible, and direct involvement of vascular surgeons in the postoperative management.

Prompt diagnosis and avoidance of unnecessary ER delays are also important issues. RAAA diagnosis relies on clinical presentation and supporting imaging, being in the early decades, mainly clinical. The diagnosis was exclusively clinical in 64.3% before 1990, and only 10% afterward. The classic triad of lumbar or abdominal pain, hypotension, and pulsatile mass was present in almost half of the patients, similar to previous reports.[24] Ultrasound and CT scanning are excellent complementary diagnostic tools, although surgical exploration should not be delayed in unstable patients.

Prognostic factors that we found to have a significant impact on higher mortality were: age ≥70 years, hypotension (≤90 mm Hg), dialysis, coagulopathy, and cardiac arrest. Only age ≥70 years, hypotension, and dialysis remained significant factors after applying multivariate analysis. Similar outcomes have been found in other series.[7,24–33]

The trend to lower mortality in recent years (from 31.4% before 1990 to 19.2% between 2010 and 2017 ($P = 0.67$)) can be explained by an improvement in diagnosis and better postoperative care.

CONCLUSION

Open repair still has a significant role in the treatment of RAAA when EVAR is not available in emergency situations. Outcomes of open RAAA repair at our institution are similar to results reported recently for OSR by USA and European Medical centers and better than some reported with EVAR in randomized trials. Mortality decreased in the last decades, with no major changes in total morbidity over time.

Limitations

The main limitation of this retrospective study is the lack of complete information on predictive variables of mortality in the first decades reviewed, which limited the analysis to only those factors with less than 10% loss of information.

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Supplementary Table I. Associated procedures performed during primary repair in 110 surviving patients (*n*, %)

Reperfusion	
Lower extremity embolectomy	14 (12.7%)
IMA artery revascularization	4 (3.6%)
Renal artery revascularization	3 (2.7%)
Lower extremity endarterectomy	3 (2.7%)
Femoro-femoral bypass	1 (0.9%)
Coronary artery revascularization	1 (0.9%)
Communication closure	
Arteriovenous fistula closure	4 (3.6%)
Aortoduodenal fistula closure	1 (0.9%)
Unexpected adverse events	
Splenectomy	2 (1.8%)
Life support	
Packing	2 (1.8%)
Pacemaker	2 (1.8%)
Open cardiac massage	1 (0.9%)
Miscellaneous	
Incisional hernia repair	4 (3.6%)
IVC filter	1 (0.9%)
Cystostomy	1 (0.9%)
Laparostomy	1 (0.9%)
Adnexectomy	1 (0.9%)